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COMPOUNDS LEACHED FROM WESTERN REDCEDAR SHINGLE TOW FOUND TOXIC TO DOUGLAS-FIR SEEDLINGS

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Shingle tow, the stringy byproduct from the manufacture of western redcedar shingles, has been used for many years as packing material around roots of forest tree seedlings. Ready availability, good moisture-holding capacity, and a tendency to retard mold development have made it popular in western nurseries (2). However, information from recent literature and preliminary test results indicate that compounds contained in shingle tow may be damaging to seedlings under some conditions.

LITERATURE SURVEY

Pathologists have credited decay resistance of western redcedar heartwood to presence of two groups of compounds, thujaplicins and polyhydric phenols (8, 10). Concentrations as low as 10 to 20 parts per million of thujaplicins strongly inhibit spore germination and growth of fungi (8, 9). In addition, thujaplicins produce detrimental effects on bacteria and on both warm- and cold-blooded animals (11, 4). Although only about one two-hundredth as toxic as the thujaplicins, polyphenols occur in heartwood at 20 to 100 times greater concentration (3). While concentration varies widely between and within trees, by weight thujaplicins average about 5,000 p.p.m. and polyphenols 100,000 p.p.m. of ovendry western redcedar wood (7).

A probable explanation for the wide-range toxicity of thujaplicins has recently been provided. Most living organisms derive a major portion of their energy via a process known as oxidative phosphorylation. Thujaplicins in concentrations of approximately 16 to 160 p.p.m. inhibit this energy-capturing system; at still lower concentrations, they "uncouple" the system or "throw it out of gear" (5). In either case, "usable" energy available to the organism is lowered, and synthetic processes such as root regeneration may be impaired.

While the effect of thujaplicins or polyphenols of western redcedar on green plants has not been reported in the literature, shingle tow or cedar sawdust has commonly been leached with water prior to horticultural use. Leaching does remove toxic compounds. In one small study[1] with outplanted ponderosa pine, only 33 percent of seedlings whose roots had been immersed for 3 hours in the solution from a shingle tow "soaking tank" survived the first growing season, compared to 90 percent survival for untreated seedlings. Because very low concentrations of these compounds affect respiration (5), the need for effective leaching is evident.

EXPLORATORY EXPERIMENTS

The first study was made to determine whether thujaplicins and polyphenols of western redcedar were toxic to 2-month-old Douglas-fir seedlings that had been grown in a greenhouse. About one-fourth of the seedlings were dormant at time of treatment.

Hot water extracts of fresh cedar sawdust were separated into a polyphenol- and a thujaplicin-containing fraction on the basis of the latter's solubility in n-hexane (6). The hexane fraction was evaporated to dryness and the residual redissolved in water. Concentration of the thujaplicin and the polyphenol solution was then determined (1, 6), and a set of four or five dilutions was made from each solution.

Groups of 15 seedlings were then randomly assigned for 2-, 26-, or 74-hour treatments in each dilution. Roots of each group of seedlings were immersed at room temperature in the assigned aerated solution for the designated time. Following treatment, trees of each group were individually potted in lightly fertilized vermiculite; all trees treated with the same chemical fraction were randomly arranged on a greenhouse bench and grown for 75 days under 16 hours of illumination per day.

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[1] Tarrant, R. F., Isaac, L. A., and Mowat, E. L. Unpublished progress report on Deschutes 1950 test on ponderosa pine field planting. February 7, 1951. On file Pac. NW. Forest & Range Expt. Sta., Portland, Oreg.

Most seedlings whose roots were immersed for 74 hours in a 160-p.p.m. solution of thujaplicins or 1,000-p.p.m. solution of polyphenols died after treatment (table 1). Some seedlings died from shorter immersion at the same concentrations or from immersion at lower concentrations for 74 hours. Both dormant and nondormant seedlings were killed, the latter somewhat more rapidly.

Table 1.--Number of Douglas-fir seedlings dead 75 days after treatment, by concentration of solution and hours of immersion[1]

Solution	Concentration	2 hours	26 hours	74 hours
	P.p.m.		Number	
Thujaplicins	0	1	0	0
	1.6	0	0	0
	16	0	0	3
	160	2	1	13
Polyphenols	0	0	1	0
	1	0	0	1
	10	0	0	2
	100	0	0	2
	1,000	0	7	13

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[1] Fifteen seedlings were used for each combination of concentration and period of immersion.

Since the polyphenols of western redcedar are largely uncharacterized, the second study was limited to the effects of thujaplicins on dormant 2-0 Douglas-firs. Seedlings were lifted from a transplant bed in early March and their roots immersed in a 65-p.p.m. thujaplicin solution for 48 hours. They were then replanted in the same way as for the greenhouse study and placed in a controlled environment chamber where they burst their buds in about 30 days. Sixty days after planting, 13 of 18 treated seedlings were dead whereas all water-treated controls were healthy. Actually, only one of the five living seedlings appeared healthy enough to survive in the field and its new needles were much shorter than those of untreated seedlings.

How do these thujaplicin concentrations compare with those found in shingle tow placed around seedling roots? The following concentrations were found in samples of shingle tow as used at three different nurseries (duplicate analyses; dry weight basis):

Nursery	Collection	Concentration (p.p.m.)
No. 1	August	<10
No. 1	November	<10
No. 1	December	18, 18
No. 2	March	15, 20
No. 3	August	100, 110

DISCUSSION

Although the techniques used in the laboratory studies do not fully duplicate field practice, they appear to have direct applicability. Seedling survival tests under greenhouse or growth chamber environment are less severe than under field conditions. Hence, mortality resulting in these studies is probably the minimum that one might expect. Under severe field conditions, lower, nonfatal but debilitating concentrations might also indirectly cause seedling deaths. For example, death might be attributed to drought whereas the primary cause could have been weakening of the seedling by an introduced toxin Such weakening seems plausible, since previous investigators have observed retarded root growth while seedlings were stored in shingle tow (2)

Analytical values obtained by laboratory extraction methods may not reflect exactly the potential effect of extractives on roots in contact with the moist surface of shingle tow in use Differences likely arise from variations in existing temperatures, in degree of root contact with the packing material, in length of exposure and in moisture content of the shingle tow Technical difficulties have thus far prevented direct determination of concentrations available to seedling roots from the packing material but preliminary results from a variety of laboratory tests indicate that potential toxic or lethal levels may sometimes exist

Evidence now available clearly shows that high concentrations of thujaplicins are damaging to Douglas-fir seedlings. Further work is needed to fully determine the effects of low concentrations Until a critical evaluation is available from work now in progress, it would seem advisable to substitute some other packing material for shingle tow

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